

a projection optical system for transferring, by exposure, a pattern of a mask as illuminated with said illumination optical system, onto a wafer.

26. (Not Amended) A device manufacturing method, comprising steps of:

applying a resist to a wafer;

transferring, by exposure, a pattern of a mask onto the wafer by use of an exposure apparatus as recited in Claim 25; and

developing the wafer having the pattern transferred thereto.

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REMARKS

Claims 1-28 are now presented for examination. Claims 9, 10, 27 and 28 have been cancelled without prejudice or disclaimer of subject matter. Claims 1-8, 11-22 and 24 have been amended to define still more clearly what Applicant regards as his invention, in terms which distinguish over the art of record. Claims 1, 2, 11, 12 and 22 are the only independent claims.

Claims 1-6, 8, 11-16, 18 and 20-26 have been rejected under 35 U.S.C. § 102(e) as anticipated by U.S. Patent 5,797,674 (Nagayama). Claim 19 has been rejected under 35 U.S.C. rejected under 35 § 103(a) as unpatentable over Nagayama in view of U.S. Patent 4,530,565 (Markle). With regard to the claims as amended by this amendment, these rejections are respectfully traversed.

Independent Claim 1 as amended by this amendment is directed to an illumination optical system in which a total reflection type light transmitting element illuminates a surface to be illuminated. In the illumination optical system, an imaging optical system forms an image of a light source by use of a light from the light source. A light collecting optical system directs light from the light source image to the light transmitting element and is effective to make the numerical aperture thereof small.

Independent Claim 2 as amended by this amendment is directed to an illumination optical system in which an imaging optical system forms an image of a light source using light from the light source. A light directing optical system directs light from the light source image to a total reflection type light transmitting element. The numerical aperture of the light directing optical system on the light transmitting side thereof is smaller than the numerical aperture of the imaging optical system on the light transmitting element side thereof. A surface to be illuminated by the illuminating optical system is illuminated with light from the light source as transmitted by the light transmitting element.

Independent Claim 11 as amended by this amendment is directed to an illumination optical system that illuminates a surface to be illuminated using an optical fiber bundle. In the illumination optical system, an imaging optical system forms an image of a light source by use of light from the light source. A light collecting optical system directs light from the light source to the optical fiber bundle and is effective to make the numerical aperture thereof small.

Independent Claim 12 as amended by this amendment is directed to an illumination optical system in which an imaging optical system forms an image of a light

source by use of a light from the light source. A light directing optical system directs light from the light source image to an optical fiber bundle. The numerical aperture of the light directing optical system on the optical fiber bundle side thereof is smaller than the numerical aperture of the image optical system on the optical fiber bundle side thereof. The surface to be illuminated by the illumination optical system is illuminated with light from the light source as transmitted by the optical fiber bundle.

Independent Claim 22 as amended by this amendment is directed to an illumination optical system in which the light has plural light beams incident on a predetermined plane at different angles. A light directing optical system directs light from the predetermined plane to a total light reflection type light transmitting element. The numerical aperture of the light emitted from the light directing optical system is smaller than the numerical aperture of the light impinging on the predetermined plane. The surface to be illuminated by the illuminating optical system is illuminated with light from the directing unit as transmitted by the light transmitting element.

In Applicant's view, Nagayama discloses an illumination optical system and an alignment apparatus suitable for reticle alignment in a projection exposure apparatus in which there is provided an illumination optical system having parallel beam supply means. For supplying a parallel beam and a light guide for guiding the parallel beam from the parallel beam supply means to a target illumination object. Diffusion means, arranged between the parallel beam supply means and the light guide diffuses the parallel beam. An incident end face of the light guide is arranged to be inclined by a predetermined angle.

According to the invention defined in Claim 1, a light collecting optical system that directs light from a light source image to a light source transmitting element is

effective to make the numerical aperture of the light smaller and in the invention of Claim 11, a light collecting optical system that directs light from a light source to an optical fiber bundle is effective to make the numerical aperture smaller.

In the invention of Claim 2, The numerical aperture of a light directing optical system directing light to a light transmitting element is smaller on the light transmitting element side than the numerical aperture of the imaging optical system supplying the light image to the light directing optical system. In the invention of Claim 12, the numerical aperture of a light directing optical system directing a light image from an image optical system to an optical fiber bundle on the optical fiber bundle side is smaller than the numerical aperture of the image optical system on its optical fiber bundle side and in the invention of Claim 22, the numerical aperture of light emitted from a light directing optical system is smaller than the numerical aperture of the light impinging on a predetermined plane supplying light to the light directing optical system.

Nagayama teaches a structure that reshapes a light beam of to increase the numerical aperture to provide a light beam of larger numerical aperture. As disclosed at lines 62-64 of column 5 in Nagayama, the use of a parallel excimer laser beam of high directivity provides a numerical aperture of almost zero and requires the increase of numerical aperture. As further disclosed at lines 39 to 49 of column 7, with respect to Figs. 9-12, "In the present invention, a diffusion means is used to spread the angle of the parallel beam (angular characteristics of luminance are shown in FIG. 11). At the same time, the parallel beam is caused to be incident on the incident end of the light guide with an angle. With this arrangement, angular characteristics shown in FIG. 12, which are close to the angular characteristics of luminance indicated by the dotted line in FIG. 10, can be

obtained. Therefore, angular characteristics exhibiting an almost predetermined luminance up to the necessary angle can be obtained on the exit side".

In view of the foregoing, Nagayama is directed to obtaining an increase in numerical aperture and away from the feature of Claims 1, 2, 11, 12 and 22 of making the numerical aperture by means of a light collecting optical system or a light directing optical system. It is therefore believed that Claims 1, 2, 11, 12 and 22 as amended by this amendment are completely distinguished from Nagayama and allowable thereover.

Claims 1-3, 5, 11-13, 15, 20, 22, 23, 25 and 26 have<sup>3</sup> been rejected under 35 U.S.C. § 102(b) as anticipated by U.S. Patent 4,497,013 (Ohta). With regard to the claims as amended by this amendment, this rejection is respectfully traversed.

In Applicant's opinion, Ohta discloses an illuminating apparatus provided with an illuminating unit that forms plural secondary light sources. The illuminating unit has a light source, a light converging device that converges photoenergy emitted from the light source, and a first multi-beam forming optical element that forms multiple light beams. A second multi-beam forming optical element produces uniform luminance distribution and forms multiple light beams. A first converging optical system converges the photoenergy emitted from the first multi-beam forming optical element on the second multi-beam forming optical element, and a second converging optical system converges the photoenergy emitted from the second multi-beam forming optical element on a photomask.

As discussed with respect to Nagayama, it is a feature of Claims 1, 2, 11, 12 and 22 that a light collecting optical system or a light directing optical system makes a numerical aperture smaller. Ohta teaches a structure using two multiple-beam forming

optical elements to produce secondary light sources of uniform light distribution. The Ohta disclosure, however, fails to suggest in any manner the light distribution characteristics at the entrance surfaces "a" and "c" of the multi-beam forming optical elements 5, 10 and 5' and 10'. Further, Ohta is devoid of any disclosure of numerical aperture or of the feature of a light collecting optical system or a light directing optical system effective to make a numerical aperture smaller as in Claims 1, 2, 11, 12 and 22. Accordingly, it is not seen that Ohta's multiple-beam optical elements and collimator lenses are relevant to the present features of Claims 1, 2, 11, 12 and 22. It is therefore believed that Claims 1, 2, 11, 12 and 22 as amended by this amendment are completely distinguished from Ohta and are allowable thereover.

Claims 1-4, 11-14 and 20-23 have been rejected under 35 U.S.C. § 102(b) as anticipated by U.S. Patent 5,559,911 (Forkner et al.). Claims 7 and 17 have been rejected under 35 § 103(a) as unpatentable over Forkner et al. in view of U.S. Patent 5,706,376 (Rykowski et al.). With regard to the claims as amended by this amendment, these rejections are respectfully traversed.

Forkner et al., in Applicant's view, discloses an optical fiber manifold provided to couple light from an illumination source to plural spaced, large diameter output fibers, or "light pipes", which are used for a variety of purposes, such as illuminating pools, spas, hazardous material zones, jail cells, and other applications where direct lighting is dangerous, difficult to maintain, or subject to vandalism. The manifold has a light converging element, which may be either a lens or a reflector, for converging light separately on each of the spaced optical fibers. The light converging element is segmented, with each segment corresponding to one of the optical fibers, and is precise enough that

substantially all of the convergent light is received by the respective cores of each of the spaced output fibers, thereby minimizing light loss.

As aforementioned, Claims 1 and 11 are featured by a light collecting optical system that directs light from a light source to an optical fiber bundle and is effective to make the numerical aperture smaller. Claims 2 and 12 are featured by a light directing optical system that has a smaller numerical aperture at a light transmitting element or fiber optic bundle exiting side. Claim 22 is featured by a light directing optical system that emits light with a smaller numerical aperture than light impinging on a predetermined plane supplying a light image to the light directing optical system. Forkner et al. is directed to an optical fiber manifold structure arranged to insure that light impinging on plural optical fibers in the manifold only enter the cores of the optical fibers. There is no teaching or suggestion in Forkner et al. relating to the light distribution characteristics at the light entrance surface of the optical fibers of the manifold and Forkner et al. is devoid of any disclosure of a "numerical aperture" with respect to a light collecting optical system or a light directing optical system at the entrance of the optical fiber manifold. Accordingly, it is not seen that Forkner et al. in any manner teaches or suggests the features of Claims 1, 2, 11, 12 and 22. It is therefore believed that Claims 1, 2, 11, 12 and 22 as amended by this amendment are completely distinguished from Forkner et al. and are allowable.

A review of the other art of record has failed to reveal anything which, in Applicant's opinion, would remedy the deficiencies of the art discussed above, as references against the independent claims herein. Those claims are therefore believed patentable over the art of record. Applicant submits that the amendments to independent

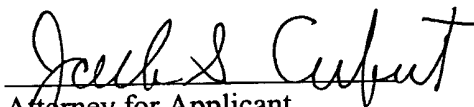
Claims 1, 2, 11, 12 and 22 clarify Applicant's invention and serve to reduce any issues for appeal.

The other claims in this application are each dependent from the independent claim discussed above and are therefore believed patentable for the same reasons. Since each dependent claim is also deemed to define an additional aspect of the invention, however, the individual reconsideration of the patentability of each on its own merits is respectfully requested.

In view of the foregoing amendments and remarks, Applicant respectfully requests favorable reconsideration and early passage to issue of the present application. The Examiner is respectfully requested to enter this Amendment After Final Action under 37 C.F.R. § 1.116.

Applicant's attorney, Steven E. Warner, may be reached in our Washington, D.C. office by telephone at (202) 530-1010. All correspondence should be directed to our address listed below.

Respectfully submitted,

  
Attorney for Applicant  
Jack S. Cubert  
Registration No. 24,245

FITZPATRICK, CELLA, HARPER & SCINTO  
30 Rockefeller Plaza  
New York, New York 10112-3801  
Facsimile: (212) 218-2200

SEW/JSC/lmj

VERSION WITH MARKINGS TO SHOW CHANGES MADE TO THE CLAIMS

1. (Twice Amended) An illumination optical system having a total reflection type light transmitting element, for illuminating a surface to be illuminated, said illumination optical system comprising:

[a luminous intensity distribution converting optical system for converting an illuminance distribution of a lamp image into a luminous intensity distribution upon a predetermined plane;

a total reflection type light transmitting element having its light entrance surface disposed substantially in coincidence with the predetermined plane] an imaging optical system for forming an image of a light source by use of a light from the light source; and

a light collecting optical system for [defining an illumination region upon a surface to be illuminated, by use of light from said] directing light from the light source image to the light transmitting element and being effective to make the numerical aperture thereof small.

2. (Twice Amended) An illumination optical system [according to Claim 1, wherein the illuminance distribution of the lamp image has an intensity which is higher at a portion adjacent to an optical axis than the intensity at a peripheral portion thereof], comprising:

an imaging optical system for forming an image of a light source by use of light from the light source;

a total reflection type light transmitting element; and

a light directing optical system for directing light from the light source image to said light transmitting element,

wherein the numerical aperture of the light directing optical system on the light transmitting element side thereof is smaller than the numerical aperture of said imaging optical system on the light transmitting element side thereof; and

wherein a surface to be illuminated by said illumination optical system is illuminated with light from the light source as transmitted by said light transmitting element.

3. (Twice Amended) An illumination optical system according to Claim [1]2, [further comprising a lamp, and lamp image forming means for forming the lamp image by use of light from the lamp] wherein the light source image has an illuminance which is larger in a portion adjacent an optical axis than in a peripheral portion about the optical axis.

4. (Twice Amended) An illumination optical system according to Claim [3]2, wherein said [lamp image forming means] imaging optical system includes an elliptical mirror [having a], wherein the light source is disposed at one focal point [whereat the lamp is

disposed] of said elliptical mirror, and wherein the [lamp] light source image is formed at another focal point of said elliptical mirror.

5. (Twice Amended) An illumination optical system according to Claim [3] 2, wherein the [lamp] light source comprises a Hg lamp.

6. (Twice Amended) An illumination optical system according to Claim [1] 2, wherein said [converting] imaging optical system includes first and second lens units having the same focal distance and being disposed so that a distance between principal points of the two lens units becomes equal to the focal distance, and wherein an entrance pupil of the first lens unit is disposed substantially in coincidence with the [lamp] light source image while an exit pupil of the second lens unit is disposed substantially in coincidence with [the predetermined plane] a light entrance surface of said light transmitting element.

7. (Twice Amended) An illumination optical system according to Claim [1] 2, wherein said [converting] imaging optical system includes an optical rod and a lens unit, wherein a light entrance surface of the optical rod is disposed substantially in coincidence with the [lamp] light source image, and wherein one focal point position of the lens unit is disposed substantially in coincidence with a light exit surface of the optical rod, while another focal point

position of the lens unit is disposed substantially in coincidence with [the predetermined plane] a light entrance surface of said light transmitting element.

8. (Twice Amended) An illumination optical system according to Claim [1]2, wherein said [converting] imaging optical system includes fly's eye lens and a lens unit, wherein a light entrance surface of the fly's eye lens is disposed substantially in coincidence with the [lamp] light source image, and wherein one focal point position of the lens unit is disposed substantially in coincidence with a light exit surface of the fly's eye lens, while another focal point position of the lens unit is disposed substantially in coincidence with [the predetermined plane] a light entrance surface of said light transmitting element.

Claim 9 has been cancelled.

Claim 10 has been cancelled.

11. (Twice Amended) An illumination optical system for illuminating a surface to be illuminated, by use of an optical fiber bundle, said illumination optical system comprising:

[a luminous intensity distribution converting optical system for converting an illuminance distribution of a lamp image into a luminous intensity distribution upon a predetermined plane;

an optical fiber bundle having its light entrance surface disposed substantially in coincidence with the predetermined plane] an imaging optical system for forming an image of a light source by use of light from the light source; and

a light collecting optical system for [defining an illumination region upon a surface to be illuminated, by use of light from said] directing light from the light source to the optical fiber bundle and being effective to make the numerical aperture thereof small.

12. (Twice Amended) An illumination optical system [according to Claim 11, wherein the illuminance distribution of the lamp image has an intensity which is higher at a portion adjacent to an optical axis than the intensity at a peripheral portion thereof] ,comprising:

an imaging optical system for forming an image of a light source by use of light from the light source; and

an optical fiber bundle; and

a light directing optical system for directing light from the light source image to said optical fiber bundle, wherein the numerical aperture of said light directing optical system on the optical fiber bundle side thereof is smaller than the numerical aperture of said imaging optical system on the optical fiber bundle side thereof;

wherein a surface to be illuminated by said illumination optical system is illuminated with light from the light source as transmitted by said optical fiber bundle.

13. (Twice Amended) An illumination optical system according to Claim [11] 12, [further comprising a lamp, and lamp image forming means for forming the lamp image by use of light from the lamp] wherein the light source image has an illuminance which is larger in a portion adjacent an optical axis than in a peripheral portion about the optical axis.

14. (Twice Amended) An illumination optical system according to Claim [13] 12, wherein said [lamp image forming means] image optical system includes an elliptical mirror, wherein the light source is disposed [having a] at one focal point [whereat the lamp is disposed] of said elliptical mirror, and wherein the [lamp] light source image is formed at another focal point of said elliptical mirror.

15. (Twice Amended) An illumination optical system according to Claim [13] 12, wherein the [lamp] light source comprises a Hg lamp.

16. (Twice Amended) An illumination optical system according to Claim [11] 12, wherein said [converting] imaging optical system includes first and second lens units having the same focal distance and being disposed so that a distance between principal points of

the two lens units becomes equal to the focal distance, and wherein an entrance pupil of the first lens units is disposed substantially in coincidence with the [lamp] light source image while an exit pupil of the second lens unit is disposed substantially in coincidence with [the predetermined plane] a light entrance surface of said optical fiber bundle.

17. (Amended) An illumination optical system according to Claim [11] 12, wherein said [converting] imaging optical system includes an optical rod and a lens unit, wherein a light entrance surface of the optical rod is disposed substantially in coincidence with the [lamp] light source image, and wherein one focal point position of the lens unit is disposed substantially in coincidence with a light exit surface of the optical rod, while another focal point position of the lens unit is disposed substantially in coincidence with [the predetermined plane] a light entrance surface of said optical fiber bundle.

18. (Twice Amended) An illumination optical system according to Claim [11] 12, wherein said [converting] imaging optical system includes a fly's eye lens and a lens unit, wherein a light entrance surface of the fly's eye lens is disposed substantially in coincidence with the [lamp] light source image, and wherein one focal point position of the lens unit is disposed substantially in coincidence with a light exit surface of the fly's eye lens, while another focal point position of the lens unit is disposed substantially in coincidence with [the predetermined plane] a light entrance surface of said optical fiber bundle.

19. (Amended) An illumination optical system according to Claim [11] 12 wherein said optical fiber bundle has a light entrance of one of square shape and rectangular shape, and a light exit face of arcuate shape.

20. (Amended) An illumination optical system according to Claim [11] 12, wherein said optical fiber bundle comprises a total reflection type fiber bundle.

21. (Amended) An illumination optical system according to Claim [11] 12, wherein said optical fiber bundle comprises a distributed refractivity type optical fiber bundle.

22. (Twice Amended) An illumination optical system [for use in an exposure apparatus for illuminating a mask having a pattern formed thereon and for projecting the pattern onto a substrate by projection exposure, said illumination optical system], comprising:

[a luminous intensity distribution converting optical system for converting a luminous intensity distribution of plural light fluxes having different incidence angles into an illuminance distribution upon a predetermined plane] light directing means for

directing light to a predetermined plane, wherein the light includes plural light beams to be incident on the predetermined plane at different angles;

a total reflection type light transmitting element [having its light entrance surface disposed substantially in coincidence with the predetermined plane]; and

a light [collecting] directing optical system for [defining an illumination region upon the mask, by use of light from said light transmitting element] directing light from the predetermined plane to said light transmitting element,

wherein the numerical aperture of the light emitted from said light directing optical system is smaller than the numerical aperture of the light impinging on the predetermined plane, and

wherein a surface to be illuminated by said illumination optical system is illuminated with light from said directing means as transmitted by said light transmitting element.

24. (Amended) An illumination optical system according to Claim 22, wherein [the plural light fluxes are supplied by] said directing means comprisess a plurality of laser light sources.

25. (Amended) An exposure apparatus, comprising:

an illumination optical system as recited in any one of Claims [1 – 24]

1-8 and 11-24; and

a projection optical system for transferring, by exposure, a pattern of a mask as illuminated with said illumination optical system, onto a wafer.

Claim 27 has been cancelled.

Claim 28 has been cancelled.